

CONAXIS – EXAMPLE 1

Modelling consolidation problem

1. Problem description

We do an consolidation analysis for a column which has two layers. The column has radius 2.0m. The first layer (clay) has height of 1.0m and the second layer has height of 0.5m. Input parameters are give in Table 1.

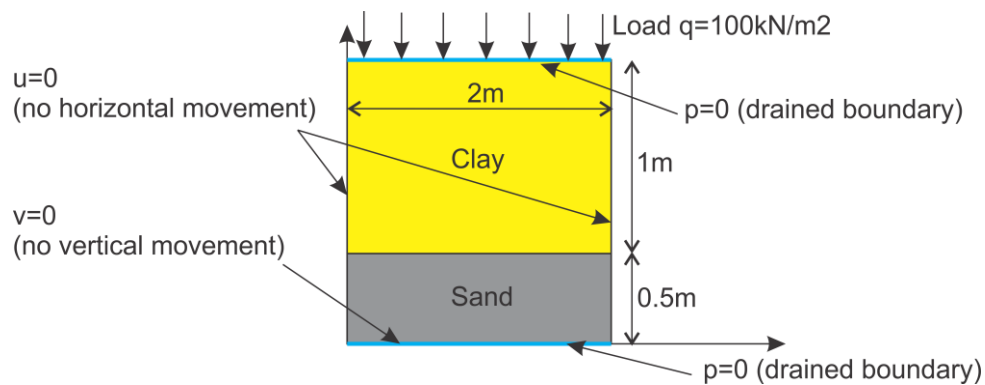


Figure 1: Problem scheme

Table 1: Input parameters

Layer	Bulk modulus	Poisson's ratio	Vertical hydraulic conductivity k_v	k_h / k_v	Void ratio
Clay	500	0.4	1e-9	2	1.8
Sand	5000	0.15	1e-5	1	0.6

The consolidation process lasts 10 day, with 100 sub-step (or the time step is 0.1 day). The column is fixed horizontally and is fixed at the bottom. The top and the bottom boundary are drained boundaries (excess pore pressure $p=0$).

For this problem, we need:

- Plot the final settlement
- Observe the change of excess pore pressure by using animation
- Get the excess pore pressure at the middle of clay ($X=1$, $Y=1$).

2. Step 1: Create a mesh

Click *Geometry/Create mesh*. A dialog pops out and we set the information as Figure 2. Click *Update* and then *Create mesh*. The final result looks like in Figure 3. If we want denser mesh, the number of sub-layer and the number of element for undisturbed zone can be modified.

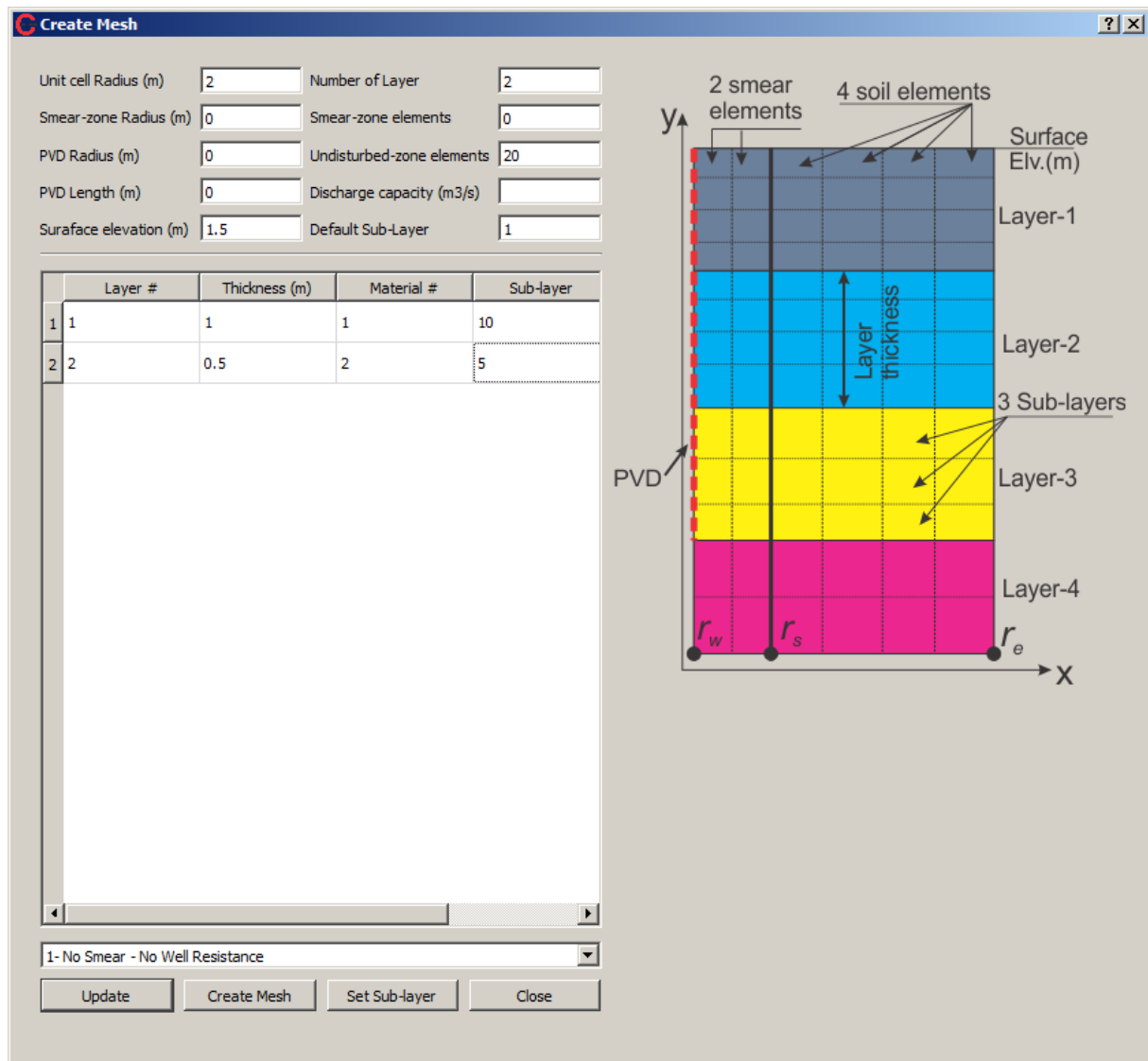


Figure 2: Creating the mesh

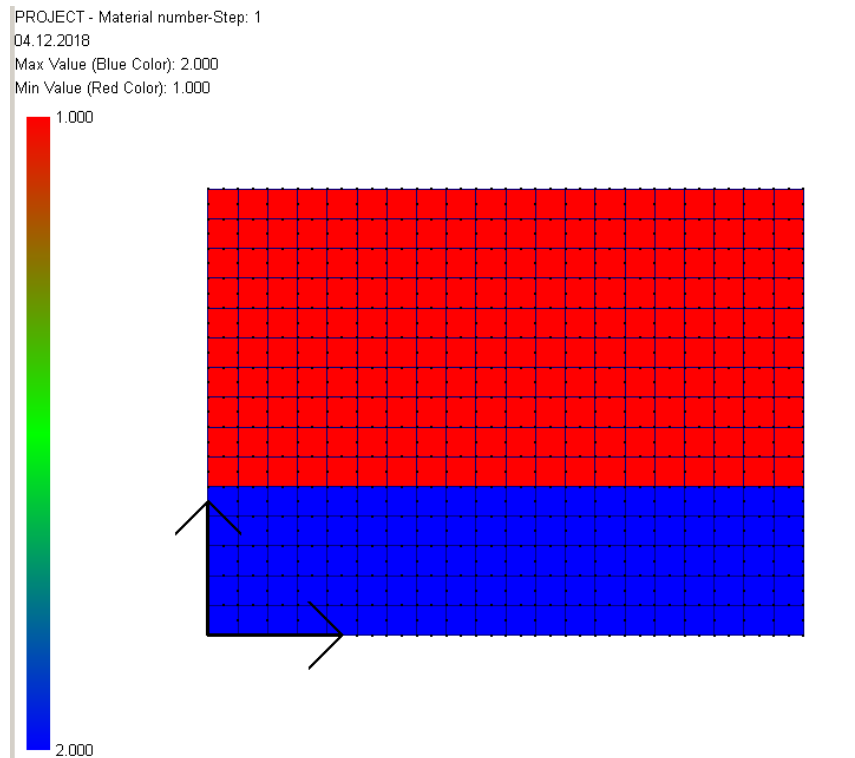


Figure 3: The final mesh

3. Step 2: Create material

Click *Create Material* from the main toolbar. We create two materials as in Figure 4.

Material #	Bulk Modulus	Constant value	Poisson's Ratio	Vertical hydraulic conductivity kv	Constant Value	Ratio kh/kv	Unit weight	Initial Void Ratio	ks/kh factor
1	Constant	500	0.4	Constant	1e-9	2	1	1.8	1.0
2	Constant	5000	0.15	Constant	1e-5	1	1	0.6	1.0

Figure 4: Creating material #1 and #2

4. Step 3: Create analysis stages

For this problem, there are two analysis stages:

- **Undrained analysis:** To generate the initial excess pore pressure after applying load on the top.
- **Consolidation analysis**

Click *Stage* from the shortcut bar. We fill in information as Figure 5.

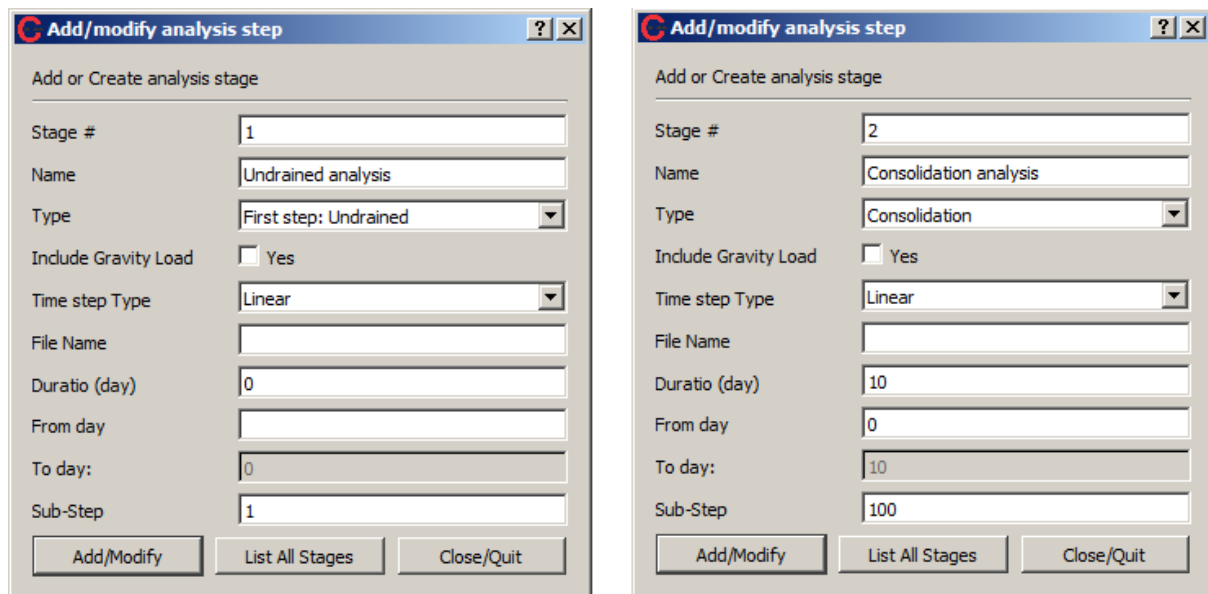


Figure 5: Two analysis stages

5. Step 4: Create boundary conditions

Four boundary conditions are needed for this problem:

- No horizontal movement (BC1)
- No vertical movement (BC2)
- No excess pore pressure (BC3)
- Load on the top boundary (BC4)

To create boundary conditions, click *Boundary Condition/Add Boundary Condition*.

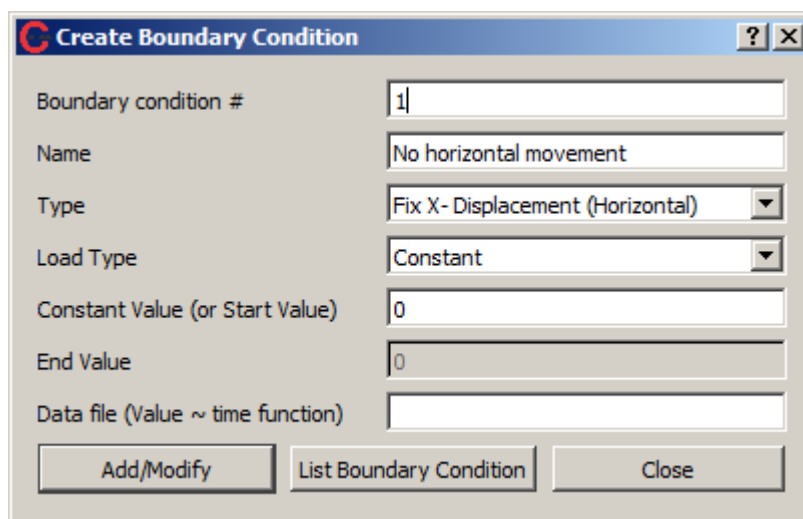


Figure 6: No horizontal movement

Create Boundary Condition

Boundary condition #: 2

Name: No vertical movement

Type: Fix Y- Displacement (Vertical)

Load Type: Constant

Constant Value (or Start Value): 0

End Value: 0

Data file (Value ~ time function):

Buttons: Add/Modify, List Boundary Condition, Close

Figure 7: No vertical movement

Create Boundary Condition

Boundary condition #: 3

Name: No EPWP

Type: Fix Pore Pressure

Load Type: Constant

Constant Value (or Start Value): 0

End Value: 0

Data file (Value ~ time function):

Buttons: Add/Modify, List Boundary Condition, Close

Figure 8: No excess pore pressure

Create Boundary Condition

Boundary condition #: 4

Name: Load on the top

Type: Line Pressure: Y- Direction

Load Type: Constant

Constant Value (or Start Value): -100

End Value:

Data file (Value ~ time function):

Buttons: Add/Modify, List Boundary Condition, Close

Figure 9: Load on the top boundary. The value is negative because the Y-direction is upward, while the load is downward.

6. Step 5: Assign boundary conditions

We need to assign boundary conditions for each analysis stage. Click *Boundary Condition/Assign Boundary Condition*.

For the undrained analysis, there is no drained boundary. Hence, only BC1, BC2, and BC4 are applied to stage-1.

- BC1 is assigned for the left and the right boundary. The left boundary has $x=0$, $y=0-1.5$. The right boundary has $x=2$, and $y=0-1.5$.
- BC2 is assigned to the bottom boundary which has $x=0-2$, $y=0$.
- BC4 is assigned to the top boundary which has $x=0-2$, $y=1.5$

Assign Boundary Condition

Analysis Stage: 1

Name of stage:

Boundary Condition (BC) #: 1 Number: 1

Name of boundary:

Assign To: Nodes with coordinate X,Y

Varied with coordinates: ☐ Yes (Value= $Ax+By+C$)

Gradient factors (A,B,C): A: 0.00000 B: 0.00000 C: 0.00000

X-Coordinate Range From: 0.00000 To: 0.00000

Y-Coordinate Range From: 0 To: 1.5

File name of list node:

Buttons: Add boundary to stage, Reset, List All Information, Close/Quit

Figure 10: Assign BC1 to the left side

Assign Boundary Condition [?] [X]

Analysis Stage: 1

Name of stage:

Boundary Condition (BC) #: 2 Number: 1

Name of boundary:

Assign To: Nodes with coordinate X,Y

Varied with coordinates: ☐ Yes (Value= $Ax+By+C$)

Gradient factors (A,B,C): A: 0.00000 B: 0.00000 C: 0.00000

X-Coordinate Range From: 2 To: 2

Y-Coordinate Range From: 0 To: 1.5

File name of list node:

Add boundary to stage Reset List All Information Close/Quit

Figure 11: Assign BC1 to the right side

Assign Boundary Condition [?] [X]

Analysis Stage: 1

Name of stage:

Boundary Condition (BC) #: 3 Number: 2

Name of boundary: No vertical movement

Assign To: Nodes with coordinate X,Y

Varied with coordinates: ☐ Yes (Value= $Ax+By+C$)

Gradient factors (A,B,C): A: 0 B: 0 C: 0

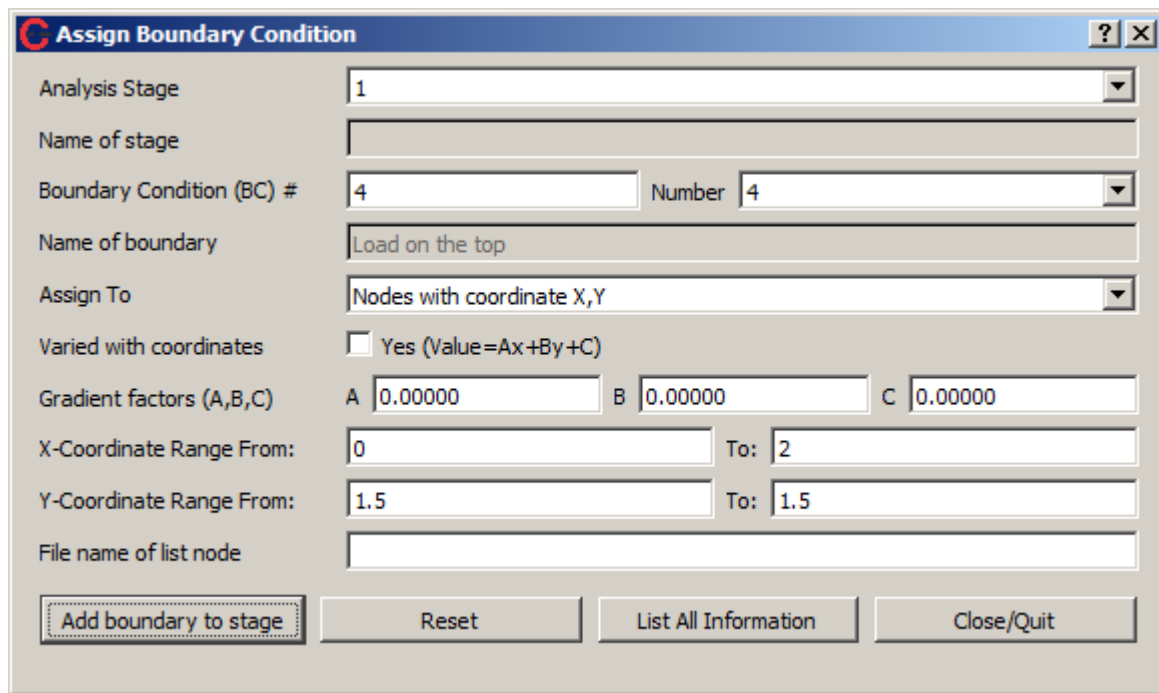
X-Coordinate Range From: 0 To: 2

Y-Coordinate Range From: 0 To: 0

File name of list node:

Add boundary to stage Reset List All Information Close/Quit

Figure 12: Assign BC2 to the bottom



Assign Boundary Condition

Analysis Stage: 1

Name of stage:

Boundary Condition (BC) #: 4 Number: 4

Name of boundary: Load on the top

Assign To: Nodes with coordinate X,Y

Varied with coordinates: ☐ Yes (Value = Ax + By + C)

Gradient factors (A,B,C): A: 0.00000 B: 0.00000 C: 0.00000

X-Coordinate Range From: 0 To: 2

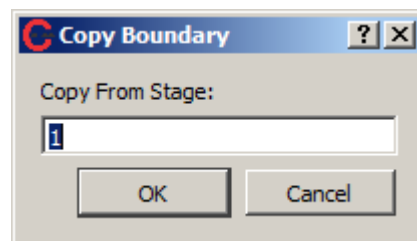
Y-Coordinate Range From: 1.5 To: 1.5

File name of list node:

Buttons: Add boundary to stage, Reset, List All Information, Close/Quit

Figure 13: Assign BC4 to the top

After finishing with stage-1, we move to stage-2. The consolidation stage has almost same boundary conditions as stage-1, except adding the BC3 to the top. Hence, we copy boundary conditions from stage-1 and then add BC3.



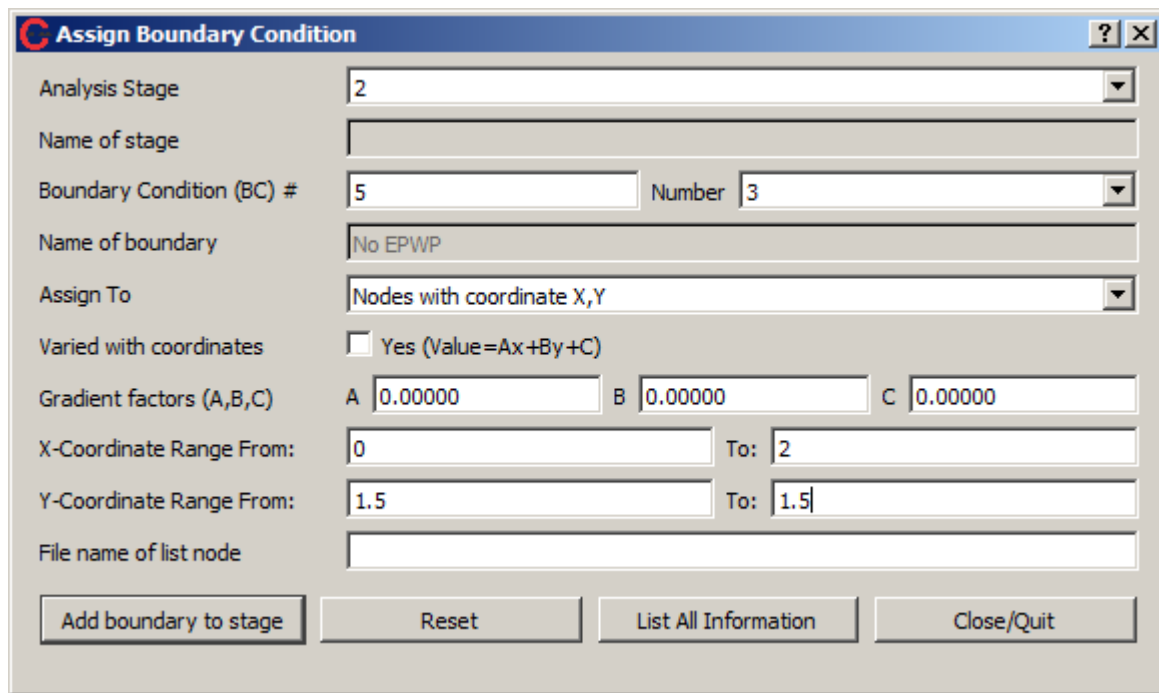
Copy Boundary

Copy From Stage:

1

Buttons: OK, Cancel

Figure 14: Copy boundary conditions from stage-1 to stage-2



Assign Boundary Condition

Analysis Stage: 2

Name of stage:

Boundary Condition (BC) #: 5 Number: 3

Name of boundary: No EPWP

Assign To: Nodes with coordinate X,Y

Varied with coordinates: ☐ Yes (Value = Ax + By + C)

Gradient factors (A,B,C): A: 0.00000 B: 0.00000 C: 0.00000

X-Coordinate Range From: 0 To: 2

Y-Coordinate Range From: 1.5 To: 1.5

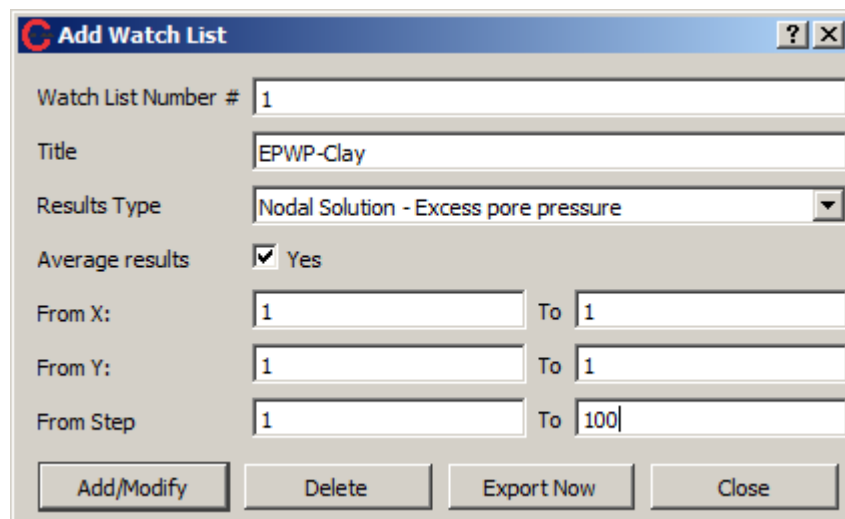
File name of list node:

Buttons: Add boundary to stage, Reset, List All Information, Close/Quit

Figure 15: Add BC3 to stage-2

7. Step 6: Define monitoring results

Since we want to get results of the EPWP of middle clay that has X=1, Y=1. We define a watch list as



Add Watch List

Watch List Number #: 1

Title: EPWP-Clay

Results Type: Nodal Solution - Excess pore pressure

Average results: ☒ Yes

From X: 1 To: 1

From Y: 1 To: 1

From Step: 1 To: 100

Buttons: Add/Modify, Delete, Export Now, Close

Figure 16: Defining a watch list

8. Step 7: Run analysis and visualize results

All the pre-processing steps are done. To run analysis, just press *Run* from the shortcut bar, or Ctrl+R.

Before running, save data to a specific folder. The data is saved under .coa extension.

To visualize the settlement at the final step, chose *Vertical Displacement* from the combo box of the left corner, click *Plot* from the shortcut bar, and fill 100 in the *Step Result* box (Figure 17).

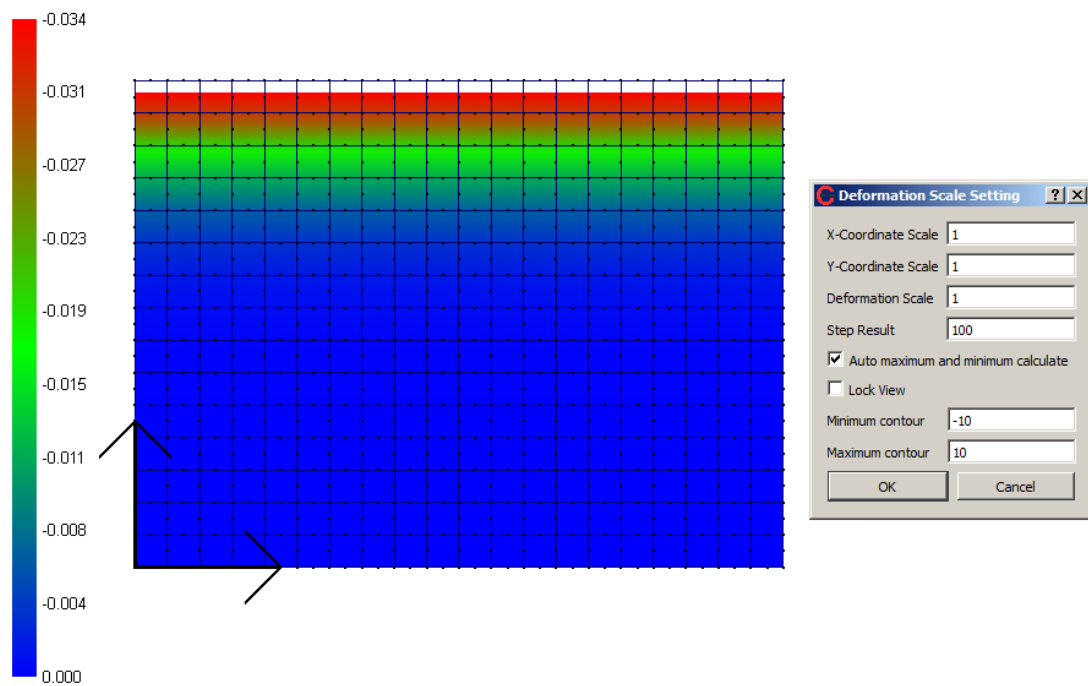


Figure 17: Final settlement

The EPWP at the final step is shown in Figure 18. To make an animation, click *Animation* from the shortcut bar and set parameters as Figure 19.

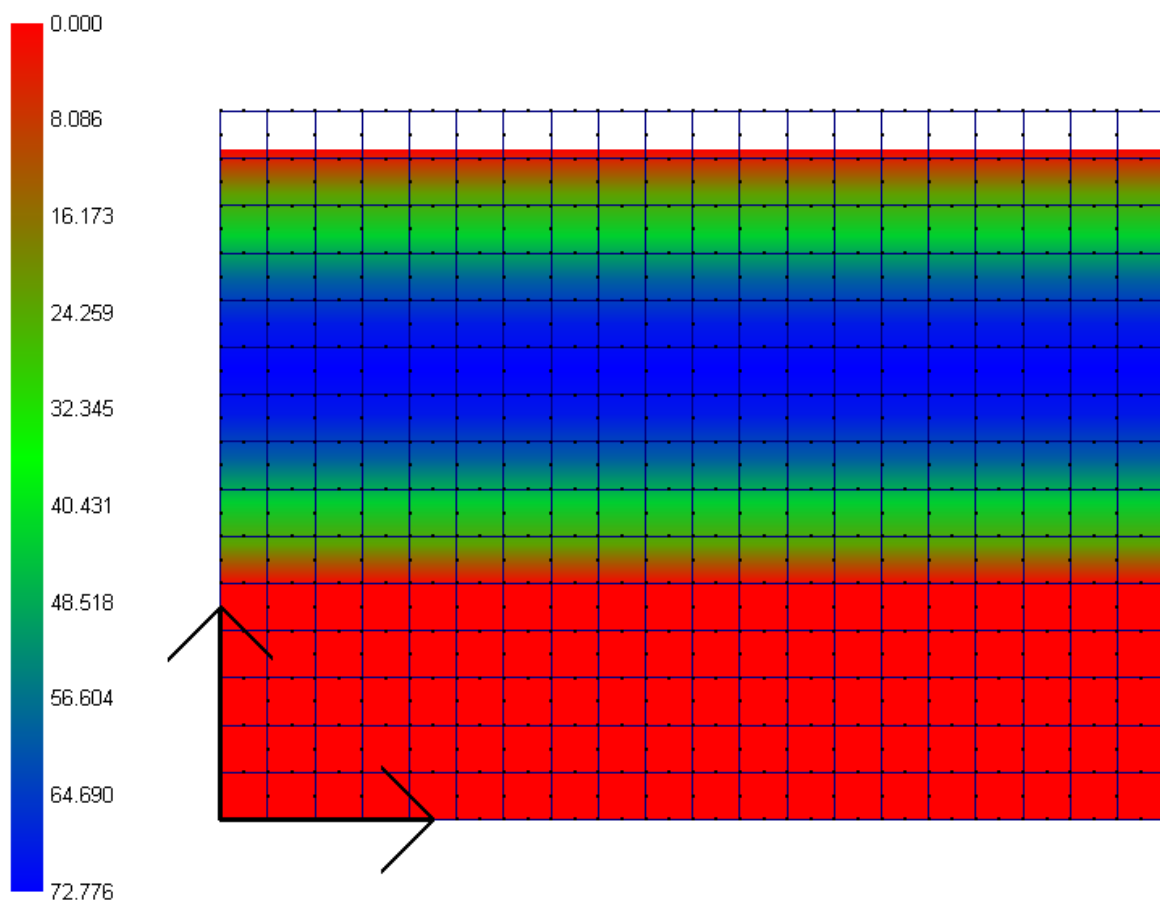


Figure 18: Excess pore pressure at the final step

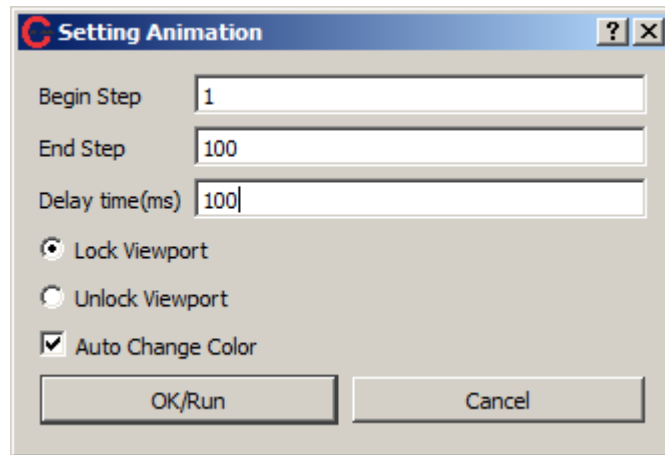


Figure 19: Creating an animation

The results at the middle of clay is saved under the file *EPWP-Clay.txt*.



EPWP-Clay.txt



nodeCoordinate_EPWP-Clay.txt

Figure 20: Watch list result